CSS/NTRES 6200
Spatial Modelling and Analysis

Raster GIS

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GIS data models

These are how spatial data are represented **inside a GIS** – *not* their conceptual representation

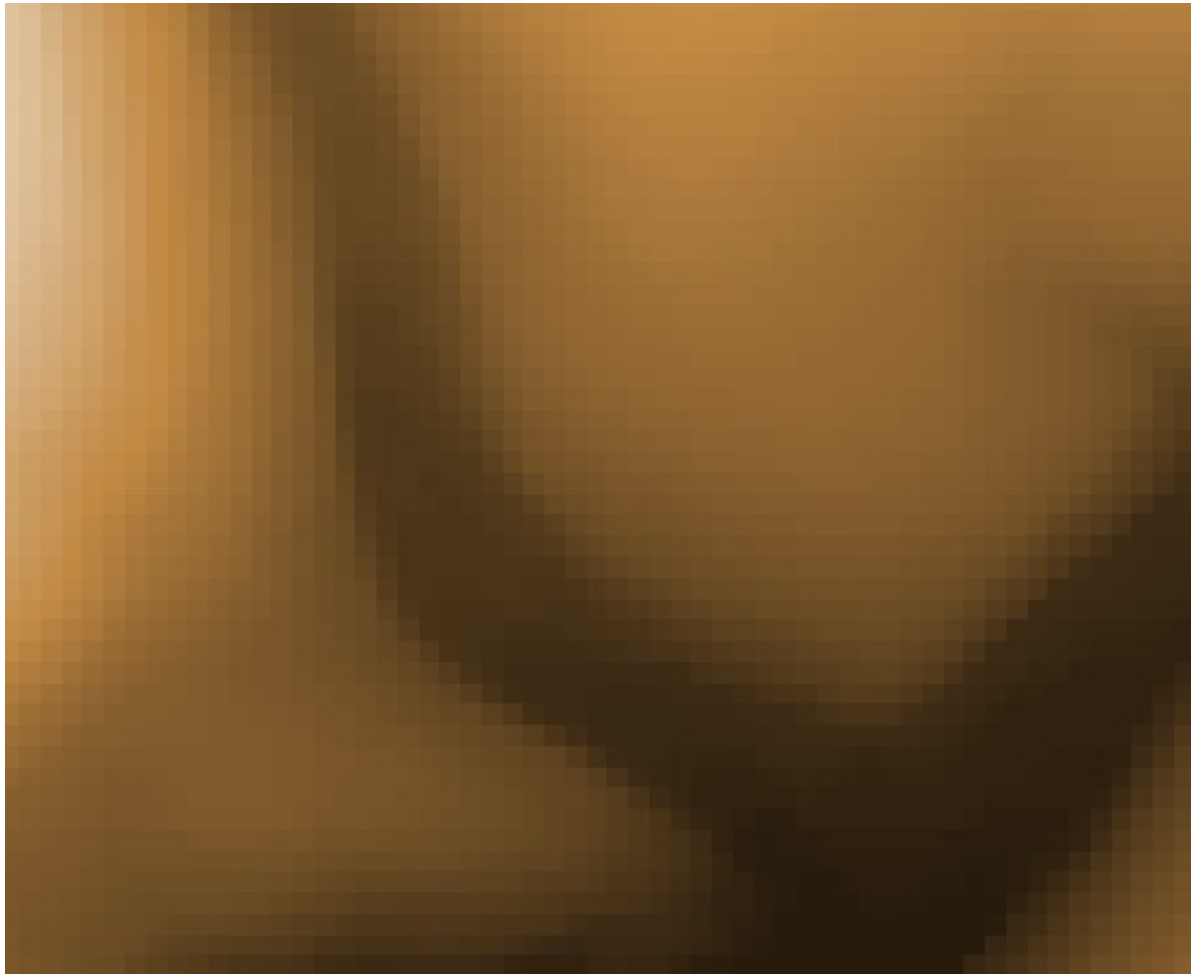
Vector exact mathematical form: 0-dimension = points; 1-dimension = line segments (which can be joined); 2-dimension = areas; 3-dimension = volumes

- Note: a Triangulated Irregular Network (TIN) is a vector data model of a 2-D continuous surface conceptual model

Raster a **regular tessellation** (e.g., square or hexagonal **grid**) of a area

- 1D: line segments; 2D: "pixels" (from 'picture elements'); 3D "voxels" ('volume pixels')
- continuous-valued raster can be considered as a **discretization** of a spatially-continuous **field**
- e.g., remotely-sensed image

Example raster DEM



CRS: EPSG:26718 - NAD27 / UTM zone 18N
10 x 10 m horizontal resolution
`.dem`: USGS Digital Elevation Model (DEM) data file

Special characteristics of rasters

- fundamental difference with vector representation: **fixed maximum resolution**, **fixed geometry**
  - can have compressed storage, e.g., quadtrees, but conceptually one resolution (the finest)

- one data value per cell; (1) **continuous** feature-space variable
  - single values at the centre point (typical for DEM)
  - grid cell (block) averages
  - direct sensor output (e.g., remote sensing), depends on **point-spread function**
  - maxima, minima, other statistical summaries of within-cell information . . .

- one data value per cell; (2) **classified** feature-space variable
  - the attribute, i.e., class name
  - a **code** linking to an **attribute table** with categories or continuous values
  - but it is more common to have a **raster stack**

Support

- **Support**: physical size of data item

- Be very clear on what the value represents; **support may not equal grid size**
  - **larger** support: one pixel in a map unit (e.g., gridded version of a vector soil map – see gSSURGO)
  - **smaller** support: "point" observation within the pixel used as its value
  - kriging: **punctual** (to grid centre) vs. **block average**; over= or ! = grid cell size

- Conversion to/from **point vector representation**
  - change of support? (not if raster value is the punctual value at the cell centre)

Example of larger support than pixel size

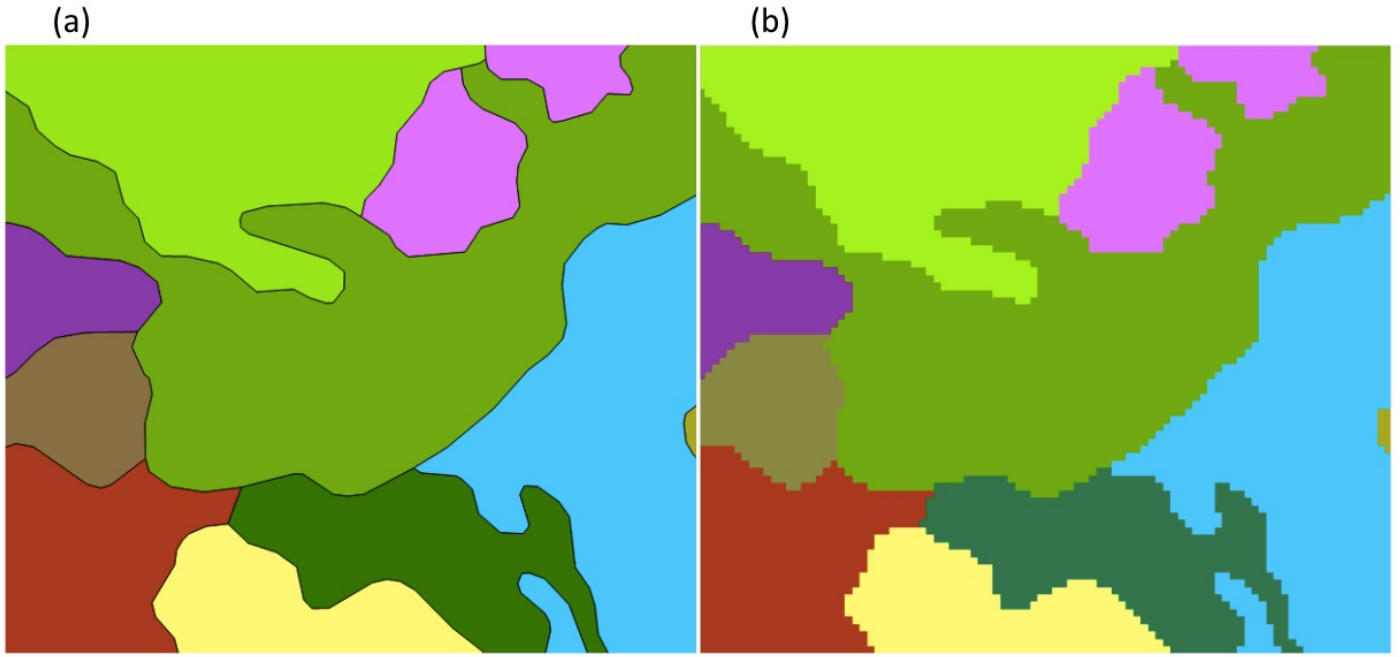
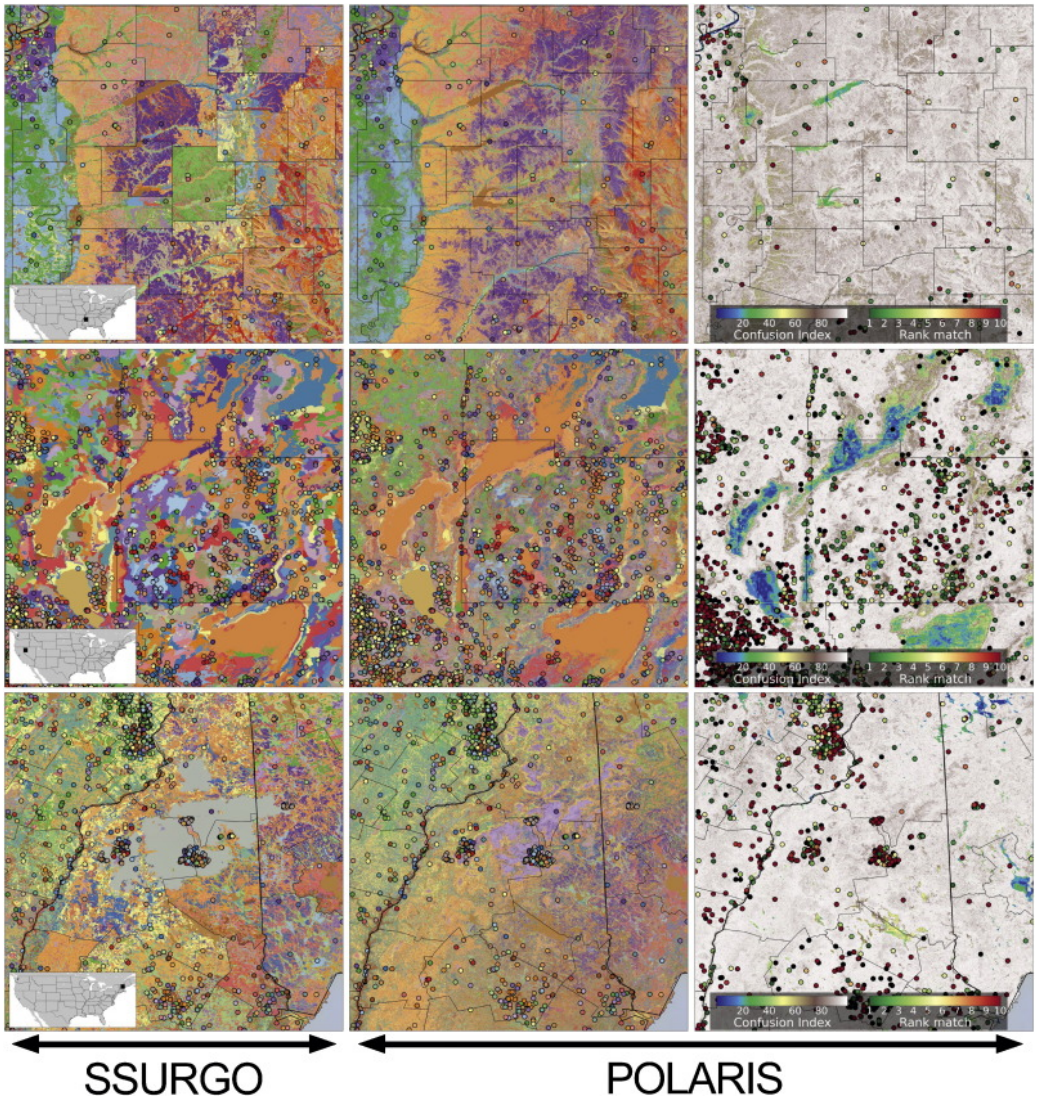


Figure 1.—(a) An example of the traditional vector-based SSURGO map unit polygon format at 1:6,000 map scale; (b) the corresponding new raster-based Gridded SSURGO (gSSURGO) 10-meter map unit format.

NRCS National Soil Survey Center, and NRCS National Geospatial Center of Excellence. 2014. Gridded Soil Survey Geographic (gSSURGO) Database User Guide, Version 1.1. NRCS.
http://www.nrcs.usda.gov/wps/PA_NRCSConsumption/download?cid=nrcs142p2_051847&ext=pdf

Example of support same as pixel size



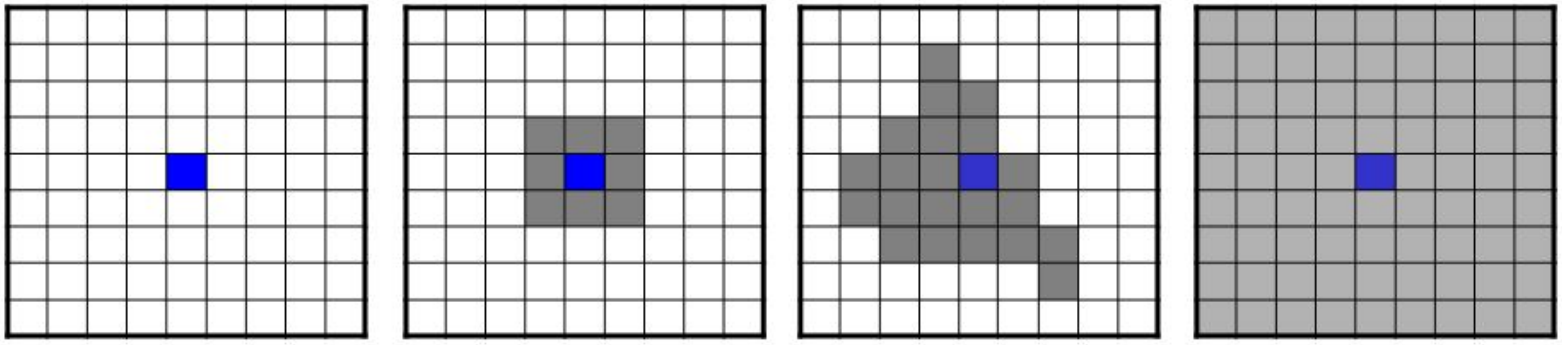
Chaney, N. W. *et al.* (2016). POLARIS: A 30-meter probabilistic soil series map of the contiguous United States. **Geoderma**, 274, 54–67. https://doi.org/10.1016/j.geoderma.2016.03.025

Operations

- overlay: very fast
- area, border, length calculations very simple -> FRAGSTATS
- categorization of operations:
  - **local**: at a pixel
    - e.g., transformations, map algebra
  - **focal**: around a pixel, in its neighbourhood
    - e.g., filter
  - **zonal**: pixel in some map unit or 'zone'
    - e.g., mean value of all pixels in the map unit
  - **global**: all pixels
    - e.g., distance from a source

Map Algebra Operations

- Tomlin (1990) defines and organizes operations as ***local***, ***focal***, ***zonal,*** and ***global*** according to the ***spatial scope*** of the operations
  - *Geographic Information System and Cartographic Modeling*, Englewood Cliffs: Prentice Hall, 1990.

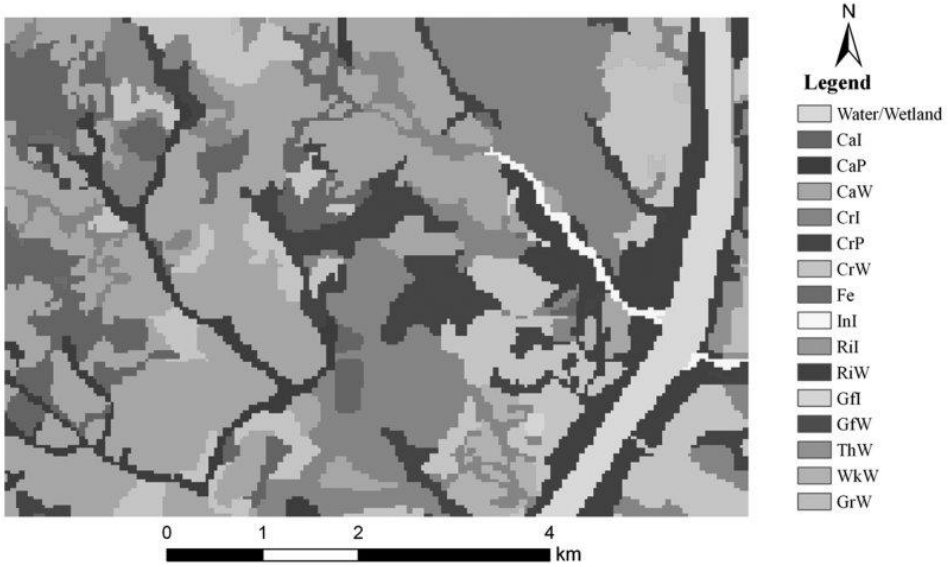


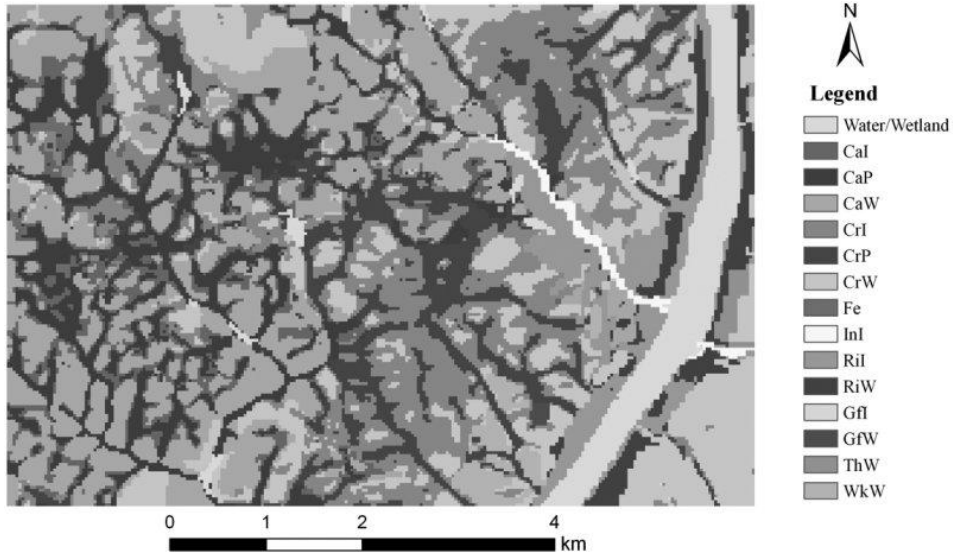
(source: Li Xingong, Univ. of Kansas)

Change of resolution

- **upscaling** by aggregation, various ways
  - central pixel
  - average, mode
  - also make uncertainty layer of σ or entropy
- **downscaling continuous-valued** rasters by image fusion with finer-resolution images, downscaling cokriging etc.
- **downscaling categorical-valued** rasters by finer-scale information and disaggregation models

Example of disaggregation





original

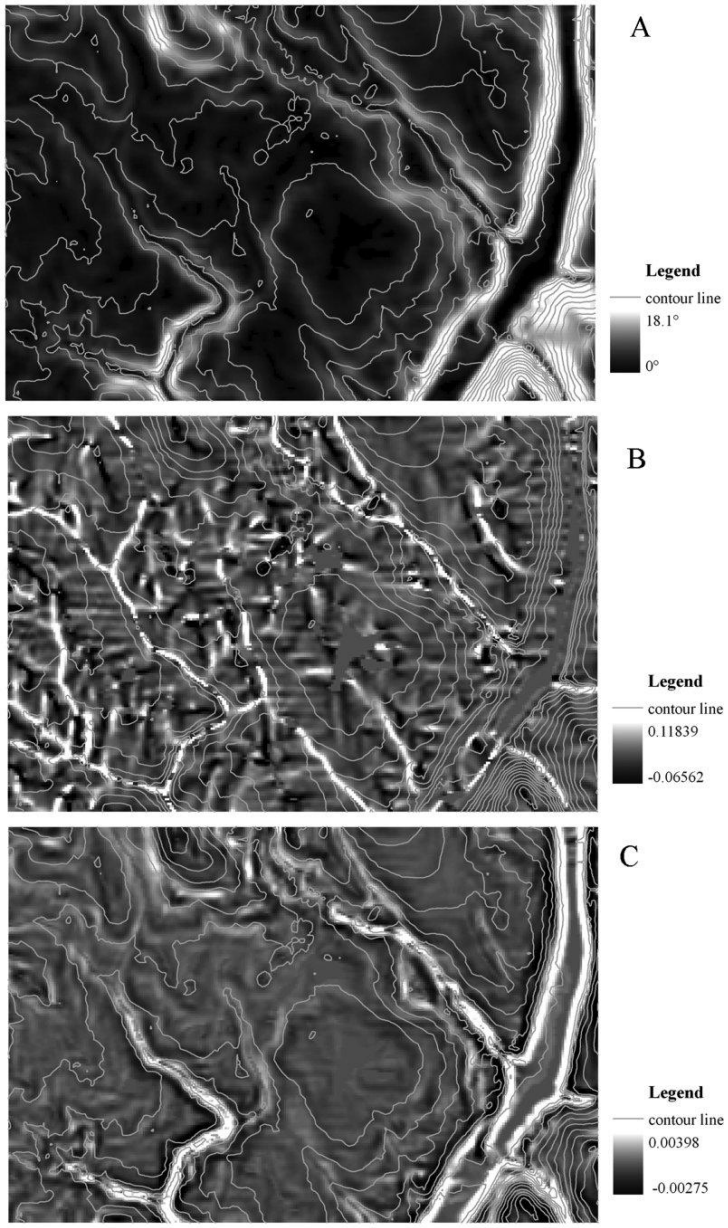
rasterized polygon map

disaggregated

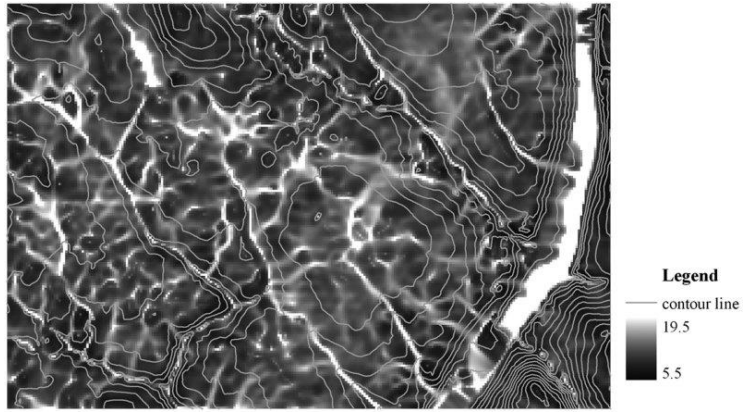
same legend, more spatial detail

source: Yang, L., *et al.*. 2011. Updating Conventional Soil Maps through Digital Soil Mapping. Soil Sci. Soc. Am. J. 75(3): 1044–1053.

Finer-scale layers used in the disaggregation model



(a) slope gradient;
(b) plan curvature;
(c) profile curvature;
(d) TWI
All these from fine-scale DEM



Adjacency, neighbours

- Adjacency, neighbour concepts very simple
- Moran's I weights can only be centroid distances or steps (queen vs. rook)